

## MANUFACTURING AIDS

A contractor's work for Lewis Research Center on "thermal barrier" coatings designed to improve aircraft engine efficiency resulted in two related but separate spinoffs. The Materials & Manufacturing Technology Center of TRW Inc., Cleveland, Ohio invented a robotic system for applying the coating and, in the course of that research, found it necessary to develop a new, exquisitely accurate type of optical gage (right) that offers multiple improvements in controlling the quality of certain manufactured parts.

Thermal barrier coatings, applied to turbine blades, combustors and other parts, act as insulators to protect against corrosion in the extremely hot engine environment. The protection thus afforded allows increasing the operating temperature of an engine by several hundred degrees, a means of increasing overall engine efficiency.

TRW's invention is a computer-aided, fully-automatic system for spraying a very hot plasma onto engine parts. Composed of a gas into which metallic and ceramic powders have been injected, the plasma forms a two-layer insulative coating. The system eliminates the need for extra machining and tooling in production of turbine blades, because the blades are made by an add-on process—adding the sprayed metal or ceramic plasma—rather than by removing metal, as most parts are made. Although the Lewis program focused on aircraft applications, the plasma-spraying system can also be used to coat industrial turbines for greater operational efficiency. NASA has granted TRW a waiver allowing the company to market the system commercially; it is already in operational service with TRW on an Air Force contract for coating aircraft engine blades.

A critical part of the coating operation is controlling the thickness of the plasma deposit, which is measured in thousandths of an inch. To assure exact coating, TRW developed an optical detector that illuminates spots at various locations on the blade, determines thicknesses by measuring reflected light, and monitors the spraying process until precise coating thicknesses are attained. The detector became the basis for the system pictured, a computerized optical gage for measuring and inspecting turbine blades, vanes and other parts with complex shapes. A variable lens focuses light on the part to be measured, then a device measures the intensity of the light reflected back to the lens; the light intensity is a basis for making measurements within a millionth of an inch. The system offers improvements in the quality of manufactured parts and provides savings through elimination of inspection variables that occur in standard methods of inspection. The gage is now in active service with TRW's Aircraft Components Group. Although it is designed specifically for use on aircraft engine blades and vanes, similar equipment could be fabricated for many other complex geometry tools, dies and components.

